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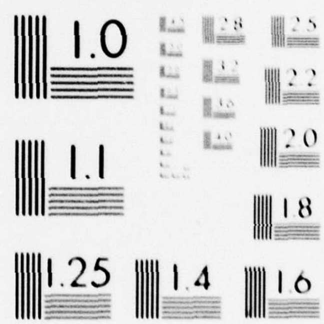

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In some areas of China, fishery production has been going downhill every year resulting in a depletion of the fish population. The effect of changing natural environmental conditions, and artificial factors are two principal reasons that may account for this downtrend. A fluctuation in natural conditions can cause the destruction of the spawning environment, an increase in predators, and/or a decrease in fish food. Artificial factors include:

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20. ABSTRACT (Continued)

the use of water birds, mammals, and small meshed nets (methods of fishing that take a considerable quantity of juvenile fish); the damming of rivers which inhibits spawning; and pollution from industries which can be toxic to fish.

Chinese freshwater fish culture has made progress in increasing fishery production; however, it has created a problem of an insufficient supply of fish fry. It is important, therefore, to thoroughly understand the breeding habit and fecundity of the fish, in addition to the physical and chemical conditions of the spawning grounds in order to devise conservation measures. For instance, when it is known that grass carp, roach, white bighead and stripped bighead spawn in certain localities in the fast water of a river, then laws can be enacted to prohibit fishing in these areas during the spawning period of each species. In nursery areas of the major economic species, small mesh nets should not be allowed. Fish ladders can be built so spawning fish can bypass the dam. Also, it is possible to create artificial spawning grounds so fish can breed below the dam. The methods used depends upon the actual conditions, including cost-benefits, engineering feasibility, etc.

CONSERVATION OF FISHERIES RESOURCES

Introduction. Although we have a rich fisheries resource, it must be wisely utilized in order to fully develop its highest potential. Like other biological resources, the fishery resource is subject to environmental influences and can fluctuate in numbers within a relatively short period. Major environmental influences may come from ecological factors or human disturbances. In this respect, there lies the basic difference between living and non-living (such as mineral) resources.

If we can control factors that are harmful to fish population, then the fish will increase in population size. On the other hand, if harmful influences are persistent, then the fish population will diminish and eventually deplete. Therefore, conservation is a very important problem in fishery production. Conservation must start with an understanding of the life cycles of the fishes and their relationship with the environment to effect measures that enable maximum development of the potential of the fish species. It is easy to see, therefore, that the basic function of conservation measures is to achieve maximum sustainable yield. Conservation and production are not contradictory to each other; rather they are complementary to each other. The ultimate goal is to make fisheries resources inexhaustable.

The fluction of sizes of a fish stock is often reflected in landing figures. In some areas in China, fishery

production has been going downhill every year, and there is a tendency of depletion in fish population. There are two principal reasons that may account for the down trend; namely, the effect of changing natural environmental conditions, and artificial factors. The fluctuation in natural conditions is quite complex, such as the destruction in spawning environment, the increase of predators, the lack of food, and other conditions. In this context, the interference by man, is often rather evident and has pronounced effects.

In the past, public fishing accounts for a large proportion of the yield of the freshwater fishery. Unique features of public fishing are its small scale, the scattering of production areas, and the fact that most fishery takes place along inshore areas. Fishing in inshore areas unavoidably results in catching a considerable quantity of juvenile fish. In small scale, widely scattered fishery, it is difficult to enforce regulation laws. And the commonest irrational gear is the small meshed nets that are being used in many areas. These nets take young fish of many economically important species.

The use of water birds and mammals such as commorants and otters to catch fish is also harmful to the conservation of fisheries resource, because these animals catch indiscriminately all sizes of fish. In fact, what they catch are mostly small, juvenile fish. Commorant fishing is quite widespread in China. These birds consume large quantities

of fish daily themselves. Besides, the product they produce is of low quality. However, such a method of fishing has its merit in rocky areas where the current is very rapid.

Generally speaking, these fish species that spawn in rivers migrate to slower-flowing accessory water bodies to feed together with their young. The most ideal places for feeding are the bays. Fishing by sealing off or damming the bay will not protect the young fish and will prevent them from returning to the rivers. This is therefore a destructive practice in northeastern China, netting a total of some 8,000,000 juvenile fish. In one of the sealed waters, over 240,000 pounds of fish were caught. This is no doubt an efficient fishing method and should be promoted, provided that the young fish can be protected. More serious is the practice of using explosives, and in some localities, the use of toxicants (such as rotenone) to catch fish. This kind of practice often results in the complete destruction of all living organisms in the water within the confines of the application.

Many species of fish must migrate to certain locations to spawn during the breeding season. During that time, fish are more densely schooled and more sluggish in their movements. They are therefore more vulnerable to fishing. Below the Three Straits of Yangtze River, where the grass carp, black Chinese reach, White bighead, and striped bighead spawn, the catch in 1955 of parent fish amounted to 1,850,000

pounds, or about 50,000 fish. This is a very harmful practice, even if we allow for a portion of the catch that comprise spawned-out fish. In the West River, fry production was seriously reduced due to indiscriminate fishing of parent stock. The carp spawn in shallow water or where there is plenty of aquatic plants or in inundated grassy areas. The public often takes this opportunity to catch the yet-to-spawn parent fish and does great damage to the population.

Freshwater fish culture in China has made tremendous progress in recent years. This is a very satisfactory phenomenon in fishery production. At the same time, however, it has created a problem, which lies in the insufficient supply of fish fry. The solution to this problem relies today, to a great extent, upon the expansion of the collection of wild fry. To effect this expansion, it is necessary to increase the fishing gear and fishing areas. One undesirable effect of this expansion is that large quantities of young fish other than the cultured species are also caught and killed.

Therefore, under the present condition of deficient supply of fish fry, catching natural fish fry is a reasonable temporary solution. But certainly this is not to be taken as a long term method. We should develop artificial culture so that it may become gradually unnecessary to depend upon natural seeds. In so doing it will not only help develop the production of fishes, but also help conservation.

Conservation measures. Effective conservation measures are based on the knowledge of life rhythms of the fish and their relation with environmental conditions. In other words, they are based on the biological foundation of fishes. Only then can conservation measures become practical and meaningful.

The fluctuation in abundance of a fish species is often reflected in annual landings. The abundance of the young often serves as an index to the abundance of the adult. It is important, therefore, to thoroughly understand the breeding habit and fecundity of the fish, as well as physical and chemical conditions of the spawning grounds. For instance, when we know that grass carp, roach, white bighead, and striped bighead spawn in certain localities in fast water of the river, we can enact laws to prohibit fishing in those areas during the spawning period. In the nursery areas of major economic species, small mesh nets should not be allowed. The breeding of the carp depends much upon the thickness of aquatic vegetation, which, in turn is directly related to water level at spawning time. During low water level years, mature carps may not spawn because of the lack of nests. Under such circumstances, large numbers of artificial nests should be provided. The carp fry, during the first day or two, like to cling to the grass in water. Therefore, care must be taken that aquatic vegetation are not disturbed during carp's spawning time.

Reasonable harvesting of commercial species is an important factor in maintaining sustained optimum yield. One of the important measures lies in the protection of immature fish. The proportion of immature fish in a catch should be regulated on the basis of actual conditions, which would allow the major portion of the population to have at least one chance to spawn. Fishing season should also be carefully regulated. In early spring spawners, fishing can be allowed in both spring and summer. Fishing for species that spawn in late spring and early summer can be best carried out during autumn. If we know the period in which the species is in the best condition, or the time when the fat content of the fish is the highest, then we can select that period as the most opportune time to fish for that species. Of course, growth rate, fatness, reproductive rate, and feeding activity vary from species to species; and we must understand them before we can enact conservation measures for each species.

In studying the breeding habits of a fish species, it is important also to find age composition and the life span. Such knowledge is essential to management of the fishery. For example, in a species that has a long life span and spawn late in life, such as the sturgeon, the adult schools should be protected from extensive fishing pressure. This is because restoration of a run is long and slow once the population becomes depleted. In species that have long life

span and spawn relatively early in life (grass carp, roach, *Elopichthys bambusa*, etc.), restoration is not rapid either; however, if the damage is inflicted upon only one generation of these species, the effect on the entire school is not too great. Only in species that are short lived and mature early and that are composed of rather few age groups, such as the pike, *Hemiculter leucisculus*, *Cirrhina molitorella*, etc., then over-fishing does not constitute a serious threat, for restoration is relatively rapid after corrective measures are taken. On the other hand, in such species, it takes only one poor year to result in a sharp drop of population.

If the objective of conservation is merely to prevent the decrease of fish population and to maintain a certain level of production, then cultivation and transplantation become far more significant ventures. In certain aquatic habitats, fish species that are not originally present can be raised. Such a method is especially useful in increasing the fish population in reservoir lakes. Both transplantation and cultivation have resulted in outstanding success in the past. For instance, the grass carp, black Chinese roach, white bighead, and striped bighead are originally Chinese fishes, but today these species are being successfully cultivated in the South Sea Islands, Japan, and eastern Europe. The fast-growing, porlific African tropical *Tilabia* has also been brought into culture in southern China. The

highly economic species, Erythroculter ilishaeformis, is very abundant in many localities but totally absent in others. The production of this particular species can certainly be greatly increased by transplantation. There are only a few limited salmonid species in the Heilung River basin in China. The climatic and ecological conditions in this area are very similar to those in Soviet Union's southern Europe and Asia. It is highly possible that some of the fast-growing, prolific, high quality salmonids in these areas can be transplanted in China's northeastern waters, especially reservoir lakes.

In transplanting, it is essential to understand the natural environment and food conditions in the water. It will be wise to transplant first these species that would most fit with the new environment.

In anadromous species, the production potential can be raised through hatchery means. Species worthy of hatchery consideration include the Chinese shad (Hilsa spp.) in Yangtze and West rivers, and chum salmon in Heilung River. Existing experience tells us that artificial propagation can be successful.

A scientific knowledge of the basic biology of the fishes can be quite useful in revealing some of the misconceptions among fishermen. It enables us to realize that although the fish is a prolific animal, its mortality rate is also very high; and that its high fecundity is simply an

adaptation to the environment. We therefore cannot take the view that just because the quantity of young fish is large, they are inexhaustible without protection. When the life cycle of young fish is understood, we know that the fry will not vanish into the ocean with the current so that we will not be sorry if the fry are not caught. We will also know that any depletion of a fish species is not due to the wanderings of the fish to an unknown locality. On the contrary, based on analyses of scientific data, we can make reliable predictions of future fishery resources and thereby to further the development of a fishery.

Freshwater fish culture will continue to develop and expand in China. There is a close relationship between culture and the stage of natural fishery resource. A rich freshwater fishery resource is a promoting force to culture.

Industrial waste water and fishery resource

The discharge of large amounts of industrial waste water into streams and lakes is not only harmful to the daily life and health of the people, but it also poses a serious threat to the fishery resource. Following the development of industry and the construction of factories, pollution caused by waste water disposal has become a very serious problem today.

The nature of waste water varies according to the kind of industry involved. Some chemicals (such as sulfides,

cyanides, lead, carbolic acid, chromic acid, etc.) are highly toxic; others while not belonging to the toxic category, can become poisonous in heavy concentrations. In the winter of 1957 and spring of 1958, fish in the lower Nen River suffered mortality due to factory effluent containing carbolic acid. Fish caught after spring thaw were of such low quality due to undesirable flavor that economic losses resulted.

Carbolic acid can penetrate through the gills of fish and get into the circulatory system and anesthetize the fish. In high concentrations, carbolic acid can cause the loss of mucous membrane in the gills and deprive the gills of gas exchange function.

Industrial waste water that contains inorganic acids (hydrochloric, sulfuric, and nitric acid), aside from causing direct damage to the gills, will lower the pH value due to the effect of hydrogen ions. The most suitable pH is 6.7-8.5 for most fishes.

Bad effects can be caused by cations from some acids. The cations of tannic acid can combine with the protein in gill cells to form insoluble substances. Acetic acid can permeate through the cell wall and cause the cell to swell, thereby reducing or damaging the ability of cells to absorb oxygen.

The ions of heavy metals such as lead, zinc, copper, mercury, silver, nickel, etc. can combine with the mucus secreted by gill membranes and fill up the interspace

between gill filaments, thereby causing mortality through suffocation. They can also cause internal injury by penetrating into internal organs interfering with the activities of enzymes. Basic substance such as sodium hydroxide will do similar damage.

Compounds such as cyanides, hydrogen sulfide, and carbon monoxide can cause toxic effects to the internal organs of fishes. These compounds can penetrate through the gills and oral cavity and get into the circulatory system, depriving the tissues the function of oxygen utilization.

Naturally, the toxic effects differ among various kinds of toxic substances. The concentration at which each substance becomes toxic also varies. It varies also according to species and size of the fish that are subjected to the toxin. The lethal dosage of various chemicals to the carp can be seen in Table 1.

Tolerances toward chemicals vary markedly among different species of fish. The carp, for instance, can tolerate carbolic acid to 100 ppm, but *Phoxinus* can tolerate the same substance only to 20 ppm; and a dose of 4 ppm is lethal to some species of mullets.

TABLE 1. Lethal dosages of chemicals to carp

Chemical	Lethal dose ppm	Chemical	Lethal dose ppm
Acetic acid	432	Nickel chloride	10
Ammonium hydroxide	2	Oxalic acid	1000
Ethyl alcohol	1000	Carbolic acid	100
Barium chloride	10000	Potassium dichromate	500
Bromine	20	Potassium cyanide	0.4
Calcium chloride	7750	Potassium permaganate	10
Chlorine	2	Sodium chloride	14000
Cupric chloride	0.018	Sodium sulfide	100

The concentration of toxic chemicals is inversely proportional to the tolerance and death time of the fish. The greater the concentration, the shorter the time required to kill the fish. However, fish will be killed instantly if the concentration gets higher than the lethal dosage.

For the convenience of utilizing water, many factories are built by the river. Consequently, waste water is emptied into the river right away. In order to prevent the harmful effects of this pollution on people's health and on fish, waste water must be treated to eliminate or reduce toxic effects before it is released into the river.

Treatment of industrial waste water can be based on physical, chemical, or biological means.

Under certain circumstances, physical treatment alone is effective. Such is the case with mineral suspensoids in water, which can be removed by precipitation. Sometimes, physical methods alone will not achieve the desired results. A combined effort of both physical and chemical means should be used. For example, in treating waste water from textile plants, toxic substances can be first coagulated by the use of certain chemicals, and then followed by the precipitation method. Sometimes biological methods can be applied in conjunction with physical and chemical methods. For instance, while treating the sulfide-containing waste water from acetate fiber plants through the use of filters, sulfur bacteria can oxidize the sulfide into sulfate.

Purification of industrial waste water must be based on economic feasibility. Treatment of waste water needs to be carried only to a degree when it is on longer harmful.

From the standpoint of protecting fish life, it is necessary to analyze the chemical constituents in the waste water, and determine the amount of suspended material, manganese compounds, pH, oils, sulfides, cyanides, carbolic acid, and various metallic substances.

It is also important to know the maximum and minimum amount of effluent, and the fluctuation in the quantity of various chemicals within a day.

The important task facing the fishery biologist in determining the harmful effects on fish life of waste

water disposal lies in the determination of the minimum tolerance levels of various toxic substances by the major economic fish species and their young. At the same time, the effect on the food organisms must also be understood. This is very important, although the effect is indirect. Laboratory experiments along these lines are already underway. This must be followed with extensive field tests before any conservation practices can be recommended.

River basin planning and development of fisheries

China is one of the countries in the world that *has* the richest water resource. The total potential of hydroelectric power in China is estimated at 540 million kw, greater than that of U.S.A., United Kingdom, France, Japan, Italy, and Canada combined. Recently the development of hydro-electric power has been rapid and tremendous. More than 10 hydro-electric stations, large and medium-sized, have been constructed, and more are on the way. With these stations have come many huge artificial lakes - reservoirs.

Multi-utilization is the fundamental principle in water system planning. Therefore, hydro-electric power stations can not only provide electricity, but at the same time, can provide flood control, irrigation, navigation, and fisheries.

The development of a water system and the development of fisheries have a close relationship. First, the construction of a dam blocks the migration route of fishes and

therefore interferes with the breading of some species. Second, because the main flow is controlled, the original ecological conditions are changed, thereby affecting fish life. Third, the inundated areas will form a large reservoir. How to utilize such a new water body for the benefit of raising fish is an important problem.

1. The effect of dams on the migration of fishes, and means of remedy. According to migratory habits, fish can be classified into anadromous, semi-anadromous, and resident kinds. Anadromous fishes are those that ordinarily live in the ocean or river mouth but move into the freshwater part of a river to spawn. Semi-anadromous species are purely freshwater fishes that migrate upriver during the breeding season to spawn. Resident fishes usually engage in relatively little migration, and they are not particular about conditions for spawning. They move short distances for feeding and overwintering.

Although anadromous species are relatively few in number in a river system, most of them are very high in economic value, such as the chum salmon in the Heilung River and the Chinese shad in Yangtze and Pearl rivers. There is a much larger number of semi-anadromous species, and most are valuable fishes; e.g., grass carp, roach, striped bighead, white bighead, Elopichthys bambusa, bream, etc. Resident species form the basic composition in Chinese waters; they also include many important commercial species

such as carp, goldfish, catfish, pike, Hemiculter leucisculus, snakehead, minnow, etc., but at the same time, the great majority of resident fishes are of small sizes.

By blocking the rivers, the dams will undoubtedly affect the spawning of anadromous and semi-anadromous fishes. For instance, the completion of the great dam on the upper Heilung River will most likely affect the spawning of chum salmon; the construction of dams at the Three Straits in the Yangtze River will probably interfere with the schools of the grass carp, black Chinese roach, white bighead, and striped bighead.

In order to maintain and develop the fisheries, it is the responsibility of the fishery biologist to call for effective measures for the protection of fishes before any damage is done.

Work along these lines is rather uncommon in China. From the experience of other nations, it has been demonstrated that effective measures are the installation of fish passages in dams. The most commonly adopted forms are fishways and fish ladders. Also, it is possible to create artificial spawning grounds below the dams so that fish can breed without passing through the dams. What the suitable method is depends upon actual conditions, including cost-benefit ratios, engineering feasibility, etc. Of course, stream planning does not necessarily have to affect the existing fishery. Recent spawning surveys in the Yangtze River serves as an example.

2. The effect of alteration of water conditions on fish life. When a dam is built across the main stem of a river, the flooded areas below the dam will be greatly reduced, thereby eliminating a large portion of spawning grounds that depended on aquatic vegetation. It is therefore essential to install artificial spawning nests at selected localities during the spawning season of certain species of fish, or to artificially breed them.

3. Utilization of reservoirs for fish propagation. After a dam is built, the forebay area will be inundated to form an artificial lake. To utilize such a large water body for fish propagation is an important consideration. We should not only increase the production of fish species that were originally present, but also introduce new species that are adaptable to reservoir conditions.

The relative importance of the three problems discussed above may change according to various conditions. Dam building in some cases can seriously affect the spawning grounds of semi-anadromous species. This particular problem, therefore, must be solved first. In ladder-type dams, the effect upon spawning of anadromous fishes in not significant, and therefore more effort should be spent in the development of fisheries there. In any event, in the planning of a water system, it is essential that fish species and other organisms that are related to fisheries be studied and that future development of fisheries be predicted.

Therefore, the principal task in fish surveys in a water system should concern the habitat, migration habit, production, and distribution of the fishes and their relationship with the natural environment. It is also important to know the kinds and abundance of food organisms, and to predict the effect of dams on these organisms. Futhermore, attention must also be paid to the economic conditions of the people in the area involved, and the conditions of communication and transportation. By so doing, the improvement of a water system will enhance, rather than adversely affect, the fisheries.